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FEEDING AND MANAGEMENT INVESTIGATIONS AT THE UNITED STATES DAIRY EXPERIMENT STATION AT BELTSVILLE, MD. 1930 REPORT

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INTRODUCTION

The facilities at the United States Dairy Experiment Station at Beltsville, Md., are devoted mainly to investigations that are planned to continue for many years. Certain phases of the various projects are completed from time to time and as they are of considerable value to the dairy industry, it appears desirable to report them promptly rather than to await the completion of the entire investigations of which they are parts. It is found possible also from time to time to conduct certain shorter experiments in feeding and management of dairy cattle without interfering with the long-time projects. These short experiments cover a wide range of subjects and most of them are of a timely and practical nature. Several of these, along with certain phases of the longer investigations, are reported herein.

A NEW METHOD FOR APPORTIONING GRAIN TO MILKING COWS

The method to be described is based upon two facts which are considered fundamental in the economical feeding of dairy cows: (1) A cow should be fed all or nearly all the good roughage she will eat; roughage is the natural food of a cow, her digestive system is adapted to handling large quantities of this kind of feed, she will not hurt herself by eating too much, and on the basis of nutrients contained, the roughage, if home grown, is generally cheaper than grain. (2) Cows should at all times, except for a few weeks after calving, receive enough feed to provide the nutrients required for the production of milk and the maintenance of body weight without any loss of weight but with no more than a small gain. The nutrients required can be estimated with a fair degree of accuracy by referring to the feeding standards which have been prepared by various investigators. These standards agree rather closely, and for all practical purposes they may be relied upon. The cow that is fed according to these standards and fails to behave as expected is the exception rather than the rule.

The ordinary method of apportioning grain is to give each cow 1 pound of grain to each 3 or 4 pounds of milk produced, depending upon the richness of the milk. This method is inaccurate for two reasons: (1) Because cows will get enough nutrients from good roughage alone to provide for the maintenance of their bodies as well as for the production of a certain amount of milk, and (2) because 1 pound of grain does not contain sufficient nutrients for as much as 3 pounds of milk. The use of this method, therefore, results in the overfeeding of low producers and the underfeeding of high producers. The low producers get fat and the high producers get thin, and not only do they get thin, but, on account of underfeeding, their milk production declines rapidly until it reaches the point at which it is provided for by the nutrients which the cows are receiving. The tendency, therefore, is to bring all members of the herd to a uniform rate of production.

Since it is not practicable on dairy farms to weigh the hay fed to each individual cow, the first step in this investigation was to determine how much hay cows of different breeds and sizes would consume when given all they would eat along with a definite quantity of silage. A few cows were fed for this specific purpose, but most of the data were gathered from other experiments in which cows had been given all the roughage they would eat. The large cows ate more roughage than the small cows, and, after their requirements for body maintenance were taken care of, the margin over maintenance was sufficient to provide for a larger milk production than in the case of the small cows. Jerseys and Holsteins of the same size ate about the same quantity of roughage. When cows were fed 3 pounds of corn silage a day for each 100 pounds of live weight, and all the No. 2 or No. 3 alfalfa hay they would eat, the small cows ate about 8 pounds of hay a day above the amount required for maintenance, whereas the large cows ate about 10 pounds above maintenance requirements. It was estimated from the Savage feeding standard that the nutrients in 8 pounds of hay would be ample for the production of 10 pounds of milk in the case of Jerseys and 10 pounds of hay would provide nutrients for at least 16 pounds of milk in the case of Holsteins.

It is assumed, therefore, that if cows are fed silage and all the medium to good hay they will eat, only those producing more than the amounts just stated will require grain. According to the Savage standard, 0.6 pound of a grain mixture in which half of the ingredients are of a bulky nature (as ground oats or wheat bran) will provide the nutrients required for 1 pound of average Jersey milk and 0.4 pound will suffice for 1 pound of average Holstein milk. The method, then, is to give grain to Jersey cows at the rate of 0.6 pound for each pound of milk produced above 10 pounds and to Holstein cows at the rate of 0.4 pound for each pound of milk above 16 pounds.

This method was given a practical trial at the experiment station of the Bureau of Dairy Industry at Beltsville for three winters. Altogether 40 Jersey cows were fed for a total of 162 cow months and 31 Holstein cows for a total of 83 cow months. The quantity of grain was adjusted on the first of each month. The hay was mostly No. 2 alfalfa, and the corn silage was of average quality. The average Jersey cow in these trials weighed 970 pounds and gave 22.5 pounds of milk a day testing 5.25 per cent butterfat; the average Holstein cow weighed 1,210 pounds and gave 36.5 pounds of milk testing 3.40 per cent. The average length of time in milk for each of these two groups was 152 days for Jerseys and 122 days for Holsteins. The Jerseys declined in production an average of 9.3 per cent from the first to the last of each month; the Holsteins declined 8.5 per cent. The Jerseys gained 5.2 pounds a month in body weight; the Holsteins, 6.9 pounds. The average daily ration for the Jerseys was 7.3 pounds of grain, 12.7 pounds of hay, and 27.6 pounds of silage; that for the Holsteins was 8.5 pounds of grain, 17.0 pounds of hay, and 35.4 pounds of silage. On the basis of average feed analyses it was estimated that the Jersey cows ate 1.9 per cent more nutrients than were required by the Savage standard and the Holsteins ate 4.6 per cent more. The Jerseys consumed 20.2 per cent more protein than was called for by the Savage standard and the Holsteins consumed 17.5 per cent more.

The grain ration used was composed for the most part of 100 pounds of hominy feed, 100 pounds of ground oats, 100 pounds of wheat bran, 50 pounds of cottonseed meal, 50 pounds of linseed meal, and 4 pounds of salt. This mixture contained, on the basis of average analyses, about 19 per cent total protein. Probably a mixture containing less protein would have given just as good results.

If the adequacy of a ration may be judged by comparison with a standard, by the gains in live weight, and by the decline in milk production, this method of feeding, on the whole, is satisfactory. The next question is, Does it provide adequate nutrients for cows in different stages of lactation and for cows giving different quantities of milk?

The cows used in this work were grouped, by breeds, according to the number of days the cows were in milk at the beginning of the calendar month selected for the experiment. Records were kept of the average daily ration for each group during the month, the consumption of digestible nutrients as compared with the requirements under the Savage standard, and the average decline in milk production and gain or loss in body weight. The purpose of this study was to determine the effect of this method of feeding upon the gain or loss in milk production and in body weight, and also to compare the nutrients received with those required. The data are given in Table 1. On account of the necessity for choosing only cows which could be used without interfering with other investigations, some of the cows were on this experiment for only a month or two. This will explain apparent discrepancies in the tables.

TABLE 1.—*The relation of days in milk to ration fed, decline in milk production, and gain or loss in body weight*

JERSEY COWS

Cows	Time in milk at the beginning of the month		Average daily ration			Digestible nutrients consumed in a month	Digestible nutrients required (Savage standard)	Average daily milk production		Average decline (−) or increase (+) in milk production from the first to the last of the month	Average weight of cows for the month	Average gain or loss in body weight for the month
	Range	Average	Grain	Hay	Silage			At beginning of the month	At the end of the month			
Number	*Days*	*Days*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Per cent*	*Lbs.*	*Lbs.*
4	15 or less.	10	11.0	12.6	28.4	602	629	27.6	33.1	+20.0	932	−44.0
12	16–45	31	10.5	11.7	28.7	567	590	29.3	27.6	−5.8	946	+10.0
18	46–75	59	11.3	11.5	27.5	583	572	28.6	26.2	−8.4	929	−4.9
23	76–105	91	9.2	12.4	27.1	541	526	26.0	23.0	−11.6	939	+7.0
21	106–135	119	6.9	12.4	28.0	490	482	22.4	19.5	−12.9	954	+9.0
21	136–165	150	5.6	13.0	28.1	479	462	19.7	17.9	−9.1	964	−3.7
12	166–195	182	5.3	14.0	29.0	483	465	18.9	17.1	−9.5	1,015	+15.0
9	196–225	211	5.4	13.0	28.4	479	471	19.3	16.7	−13.5	1,004	+14.0
7	226–255	243	3.3	15.8	30.1	472	442	15.0	13.9	−7.3	1,064	+11.0
4	256–285	276	3.0	13.7	25.5	422	427	15.1	13.7	−9.3	1,001	+32.0
HOLSTEIN COWS												
3	15 or less.	8	8.9	16.9	34.0	648	655	36.8	40.1	+9.0	1,151	+4.3
9	16–45	31	11.9	16.5	37.4	721	709	43.2	41.7	−3.5	1,218	−8.4
14	46–75	63	11.4	17.0	36.1	715	689	43.3	41.0	−5.3	1,219	+8.8
13	76–105	92	9.4	17.3	34.7	646	603	39.6	34.9	−11.9	1,175	+10.8
10	106–135	122	7.3	18.1	34.5	632	592	34.5	31.6	−8.4	1,207	+6.3
6	136–165	148	3.4	17.2	34.0	512	489	24.5	21.0	−14.3	1,222	+11.8
3	166–195	181	3.5	[1] 13.7	34.3	481	525	24.9	19.9	−20.1	1,226	−5.7

[1] Low consumption due to abnormal behavior of one cow.

Except during the first month or so after calving the cows consumed all the digestible nutrients required; the declines in milk production were not unduly large at any stage of lactation; and, after the first month or two there was, in general, a small gain in weight.

The cows were next grouped, by breeds, according to the quantity of milk produced. The Jerseys fell into five groups, ranging from those giving less than 10 pounds to those giving more than 40 pounds of milk. The Holsteins fell into six groups, ranging from those giving less than 20 pounds to those giving more than 60 pounds of milk. The results under this grouping are given in Table 2.

TABLE 2.—*The relation of milk produced to ration fed, decline in milk production, and gain or loss in body weight*

JERSEY COWS

Cows	Daily milk yield at the beginning of the month		Average daily ration			Digestible nutrients consumed in a month	Digestible nutrients required (Savage standard)	Average time in milk at beginning of the month	Average daily milk yield at end of the month	Average decline (−) or increase (+) in milk production from the first to the last of the month	Average weight of cows for the month	Average gain or loss in body weight for the month
	Range	Average	Grain	Hay	Silage							
Number	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Days*	*Lbs.*	*Per cent*	*Lbs.*	*Lbs.*
2	40.1–41.2	40.7	17.6	10.4	26.0	680	719	65	38.3	−5.9	901	−10.0
29	30.1–40.0	34.3	13.4	12.0	28.6	642	640	70	31.4	−8.5	945	+1.0
51	20.1–30.0	24.8	8.4	12.4	27.3	523	509	123	22.2	−10.5	937	+4.5
60	10.1–20.0	15.1	3.1	13.6	29.3	438	432	216	13.7	−9.3	1,025	+6.8
4	10 or less.	8.1	0	14.7	29.5	387	328	200	6.8	−16.0	1,010	+14.0

HOLSTEIN COWS

Cows	Range	Average	Grain	Hay	Silage	Digestible nutrients consumed in a month	Digestible nutrients required (Savage standard)	Average time in milk at beginning of the month	Average daily milk yield at end of the month	Average decline (−) or increase (+) in milk production from the first to the last of the month	Average weight of cows for the month	Average gain or loss in body weight for the month
23	60.1–74.2	66.9	22.5	17.4	41.0	954	974	42	70.2	+4.9	1,384	−36.0
9	50.1–60.0	52.3	14.7	17.7	35.6	786	732	65	50.2	−4.0	1,143	+16.1
11	40.1–50.0	45.1	11.6	17.3	36.8	727	705	86	41.4	−8.2	1,248	−4.5
21	30.1–40.0	34.4	7.6	16.1	34.3	602	603	90	32.1	−6.7	1,193	+6.0
16	20.1–30.0	24.0	3.2	17.5	34.7	528	491	200	20.5	−14.6	1,201	+9.2
6	20 or less.	15.3	.4	19.0	35.2	496	406	174	9.9	−35.3	1,211	+22.5

All of the cows, except a few of the highest producers, ate enough nutrients to meet their requirements for both maintenance and milk production, and the few exceptions failed by only a small margin. The highest producers lost some weight, which may be explained, at least in part, by the short time that had elapsed since calving. The rest of the cows in most cases made satisfactory gains in weight. The declines in milk production are about such as would be expected, except for the lowest producing group of Holsteins. Three of the six cows in this group were drying off rapidly and were entirely dry within 10 days after being taken off the experiment. The fact that they were at the same time making good gains in weight would encourage the belief that the method of feeding was at least not wholly responsible for the abnormal decline of this group.

While the cows used in these experiments were Jerseys and Holsteins, the method may be applied in like manner to other breeds of dairy cows, as follows: Give Guernsey cows grain at the rate of 0.55 pound of grain for each pound of milk produced above 12; give Ayrshire and Brown Swiss cows 0.45 pound of grain for each pound of milk produced above 14 pounds.

For comparison of this new method of feeding grain to dairy cows with the usual method of feeding 1 pound of grain for each 3 or 4 pounds of milk produced, it would have been desirable to have had similar data on the production, decline in milk yield, and gain or loss in body weight of cows fed by the usual method. However, if the nutrients provided by each of these two methods of feeding are compared with those provided by the Haecker and Savage standards it will be found that, as a rule, this new method more nearly supplies the nutrients in the amounts prescribed by the standards than the one in common use. Furthermore, the results of experimental feeding here reported show that the nutrients were actually supplied in very nearly the correct amounts.

This method is not presented with the idea that it will apply to all conditions, but it does apply in all cases where silage and a good quality of hay is provided for the herds. The following hays, if cut reasonably early and so cured as to retain most of the leaves and much of the natural green color, will be eaten in such quantities that the grain may be apportioned as suggested: Alfalfa, soybean, timothy, and mixed timothy and clover. Timothy hay and silage alone do not contain sufficient protein for the low producers, which should receive either some hay containing more protein or a high-protein concentrate. Palatability tests have been made at Beltsville with alfalfa, soybean, and timothy hays.

The method does not apply with accuracy to the irrigated sections of the West where hay of excellent quality is grown, nor will it apply to those sections where a poor roughage is used, as straw, corn stover, cottonseed hulls, or coarse or weather-damaged hay. In the former case the excellent roughage alone will support a production much in excess of 10 pounds for Jerseys and 16 for Holsteins; in the latter case the poor roughage given will not provide the nutrients for as much as 10 and 16 pounds, respectively. Furthermore, in the application of this method certain improvements appear desirable. For example, Jersey cows producing milk containing less than 5 per cent butterfat may be fed 0.5 pound of grain instead of 0.6 pound, and those producing milk containing more than 6 per cent may be fed 0.7 pound of grain for each pound of milk produced above 10 pounds.

There is some question, too, whether this method may be safely used without modification for feeding high-producing cows. It is common knowledge that heavy grain feeding may throw a cow "off feed." Whether this will happen if the cow is receiving no more total nutrients than she needs has not been determined. The safest plan is to limit the grain ration to about 1½ pounds a day for each 100 pounds of live weight. The difference between this amount of grain and the required amount can be made up with dried beet pulp, considering the pulp equal, pound for pound, to an ordinary grain mixture. The pulp may be fed either wet or dry. The reason for substituting beet pulp for grain is because cows are apparently not injured by heavy feeding of beet pulp. Another way by which the grain might be kept at a safe level for high producers is by feeding some root crop to compensate for any deficiency in grain requirements.

Another point on which further assurance is needed is whether cows are properly nourished on a ration of roughage alone. The appearance and the gains in weight of the cows in these experiments when fed roughage alone indicate satisfactory nourishment, although certain investigations suggest the possibility of a phosphorus deficiency. If future work shows the need for additional phosphorus, the method of feeding described above should be revised to include feeding some material such as wheat bran or bone meal to the low producers.

FEEDING COTTONSEED MEAL TO DAIRY COWS

In making up the grain ration for dairy cows many dairymen avoid the use of cottonseed meal. Doubtless their objection can be attributed to the bad effects which have sometimes attended the feeding of cottonseed meal in considerable quantities to swine and calves, also to certain instances of blindness and other troubles observed in beef steers. On the other hand, many dairy cows have remained in apparently perfect health even after years of liberal cottonseed-meal feeding. The feeding trials reported below were intended to bring about the so-called cottonseed-meal injury, in order to permit a study of its causes. A brief statement of the trials conducted and the results follows.

Cow 91, a sterile grade Holstein, for 69 days was fed 16 pounds of cottonseed meal a day, along with either pasture and silage or alfalfa hay and silage. The meal fed during this part of the experiment was made at Leland, Miss. This period was followed by feeding her 10 pounds a day for 72 days on meal obtained from Dallas, Tex. With the idea that the cottonseed meal made in the western part of the Cotton Belt may have been less toxic than that made in the eastern part, some meal was obtained from South Carolina and the feeding of 10 pounds a day continued for 214 days. As no harmful effects were yet apparent, wheat straw was substituted for the alfalfa hay and silage, the allowance of meal remaining unchanged. This continued for 84 days. There were no symptoms of cottonseed-meal injury at any time. A post-mortem examination revealed no unusual condition. This cow was dry most of the time and sterile all the time.

Cow 97, another sterile grade Holstein, was fed the Mississippi meal for 84 days, at the rate of 10 pounds per day, along with pasture, silage, and alfalfa hay. Although she remained a nonbreeder, there was a very obvious improvement in her general condition.

Cow 82, a grade Holstein and a difficult breeder, was fed similarly for 4½ months. She failed to conceive, but otherwise her health remained good.

Heifer A–29, a grade Jersey, supposedly sterile, was fed 4 pounds of cottonseed meal a day for six weeks, then 6 pounds a day, along with either alfalfa and silage or pasture. Five months after the feeding started she conceived, carried her calf full time, and conceived again on the first service. The feeding of cottonseed meal was discontinued after she was first pronounced pregnant.

Cows 64 and A–2, both grade Holsteins, were each fed 10 pounds of cottonseed meal per day for 16 and 17 months, respectively, along with pasture or alfalfa hay and silage. The feeding of cow 64 started when she had been pregnant 148 days, and of cow A–2 when she had been pregnant 16 days. Both cows dropped full-time normal calves. The condition of the cows as regards flesh and general health remained good throughout the entire period. Cow A–2 conceived 7½ months after calving. Cow 64 had adhesions around the Fallopian tubes, which prevented conception.

In another experiment, five Jersey cows fed 6 pounds per day of cottonseed meal each for 144 days showed no ill effects.

All of the above-mentioned cows, except cow 91 for 84 days, received good roughage with their cottonseed meal. This roughage was pasture grass alone, or pasture grass with silage, or alfalfa hay and silage. Four dry, supposedly sterile cows were fed a poorer roughage with their cottonseed meal, with the following results:

Cow 468 was fed 10 pounds per day of cottonseed meal with timothy hay alone or silage alone, or with both the hay and silage, for four months. No bad effects were observed, but she remained sterile. This cow actually ate about 8 pounds of the meal per day.

Cow 279 was fed about the same as cow 468, with the same result.

Cow 442 was fed 10 pounds per day of cottonseed meal and timothy hay for 5½ months, then wheat straw in place of the timothy for 39 days. No bad effects were observed. Sterility persisted.

Cow 490 was fed 10 pounds of cottonseed meal per day and silage for six months. Her health remained good, and she conceived in 4½ months.

All the cows used in these experiments were fed cottonseed meal to ascertain its effect upon their health. Large quantities were fed, with the idea that if no apparent harm resulted it would be safe to conclude that smaller quantities would also be harmless.

The findings with these cows are in accord with results obtained at the Michigan, North Carolina, Oklahoma, and Texas State Agricultural Experiment Stations. It appears that cottonseed meal is harmless to cows if good roughage, such as pasture grass, green forage, or nicely cured hay, is fed with it. The only trouble from feeding cottonseed meal to dairy cattle, to which the writers have been able to find reference in the literature, occurred when it was fed along with either cottonseed hulls, as at the North Carolina station, or with wheat straw, as at the Michigan station.

Eight of the cows used in the Beltsville experiments had given much breeding trouble and appeared to be permanently sterile. Two of these eight conceived after several months of feeding on cottonseed meal. As the cottonseed meal appeared to help in getting these two cows pregnant, other heifers and cows that had been bred several times without success were fed cottonseed meal for the purpose of inducing conception. Data on 22 of the animals, which have been fed cottonseed meal for as long as two months, are shown in Table 3.

TABLE 3.—*Services before and after feeding cottonseed meal, time of conception, and pounds of cottonseed meal fed*

Animal No.	Services before cottonseed meal was fed	Services after feeding of cottonseed meal was started	Date feeding of cottonseed meal started	Date of conception	Time elapsing after starting cottonseed meal feeding before date of conception	Quantity of cottonseed meal fed per day
	Number	*Number*			*Days*	*Pounds*
A-44	3	0	Nov. 12, 1929	Nov. 10, 1929		4
A-43	2	2	June 29, 1929	July 23, 1929	24	6 and 4
A-42	3	1	Nov. 20, 1928	Dec. 16, 1928	26	4
A-39	4	3	Apr. 17, 1928	June 30, 1928	74	4
A-38	5	1	Apr. 20, 1928	May 20, 1928	30	4
A-37	8	0	July 1, 1928	June 17, 1928		4
836	7	0	Feb. 2, 1930	Jan. 26, 1930		4
A-14	4	2	May 1, 1928	June 12, 1928	42	4
A-19 [1]	4	0	Jan. 22, 1928	Jan. 21, 1928		10 and 4
A-2 [1]	7	0	Jan. 21, 1928	Jan. 5, 1928		10
A-13	6	1	Mar. 24, 1929	Apr. 1, 1929	8	6
A-28 [2]	3	1	Apr. 11, 1929	(3)		4
652	12	1	Mar. 20, 1930	Mar 24, 1930	4	6
601 [4]	16	7	Apr. 11, 1930	(3)		6
603 [4]	12	5	do	(3)		6
455 [4]	7	3	June 18, 1930	(3)		6
632	5	0	do	June 12, 1930		6
689	11	0	do	June 11, 1930		4
1008	6	3	do	Aug. 18, 1930	61	4
1009	5	0	do	June 6, 1930		3
838	5	1	do	June 23, 1930	5	4
802	5	0	do	June 14, 1930		6

[1] Not fed cottonseed meal for purpose of inducing conception.

[2] Affected with lumpy jaw; died July 9, 1929

[3] Did not conceive.

[4] Post-mortem examination showed conditions that would make conception difficult or impossible.

The results so far have been most encouraging. The four failures experienced in bringing about conception have been with diseased animals; one cow had lumpy jaw, and autopsy revealed severe genital troubles in three others. The large proportion of animals that conceived to a service immediately before cottonseed-meal feeding started suggests the possibility that cottonseed meal may have been useful in bringing about implantation of the fertilized egg. This same condition has been noted in the feeding of germinated grains to correct certain forms of sterility in cows of the Beltsville experimental herd.

PALATABILITY OF BONE MEALS

Investigations at the Minnesota and Michigan Agricultural Experiment Stations have shown the value of bone meal in correcting certain mineral deficiencies in the rations of dairy cows. It has also been very well demonstrated, in both a practical and scientific way, that when the rations contain plenty of assimilable calcium and phosphorus as normal constituents of the feeds, there is no advantage in supplying additional amounts of these minerals. There are many times, however, when the rations are deficient in these elements, and there are other times when the adequacy of the rations in either calcium or phosphorus or both is in doubt.

The purpose of this investigation was to find the kind of bone meal that is most palatable, and also to determine the quantities that would be eaten when cows are allowed free access to it for a part of every day. As it is well known that cows suffering from lack of minerals have a craving for bones and other substances, it was thought possible that dairy cows might take care of their own needs for calcium and phosphorus just as they do for common salt, if they had access to bone meal in a palatable form.

The four products used, and their analyses for moisture and ash, are as follows:

TABLE 4.—*The content of moisture and ash in different bone meals*

	Moisture	Ash
	Per cent	*Per cent*
Special steamed bone meal	2.8	73.9
Poultry bone meal, finely ground	6.7	61.7
Poultry bone meal, coarsely ground	7.1	58.3
Raw bone meal	8.8	60.8

The so-called raw bone meal had been steamed to practically the same degree as poultry bone meal.

Forty cows were allowed free access to salt, special steamed bone meal, and finely ground poultry bone meal, in separate covered boxes in the yard for two hours or more every day from December 4 to February 4, inclusive. During the period of this experiment no salt was placed in the grain mixture which the cows were receiving. They ate 98 pounds of salt, 3 pounds of special steamed bone meal, and 155 pounds of poultry bone meal. This experiment shows plainly that the poultry bone meal was more palatable than the special steamed bone meal, and confirms results obtained at the Iowa Agricultural Experiment Station.

On February 12, 1930, an experiment was started to test the palatability of finely ground poultry bone meal, coarsely ground poultry bone meal, and "raw" bone meal. Only four cows were used. Two of these (A–13 and A–18) were milking heavily and two (A–29 and A–41) were only average producers. The grain ration was purposely made up so as to contain but little phosphorus. It consisted of 300 pounds of ground oats, 50 pounds of corn gluten feed, 50 pounds of soybean meal, and 4 pounds of salt. Every night a small box of bone meal was placed in the manger of each cow and taken out each morning. The roughage consisted of No. 2 alfalfa hay and silage. The experiment was discontinued when the cows were turned on pasture April 21, 1930. The amounts of the different bone meals eaten are given in Table 5.

Table 5.—*Quantities of different bone meals eaten by four cows*

Cow No.	Finely ground poultry bone meal			Coarsely ground poultry bone meal			"Raw" bone meal		
	Total quantity eaten	Period of trial	Average daily consumption	Total quantity eaten	Period of trial	Average daily consumption	Total quantity eaten	Period of trial	Average daily consumption
	Pounds	*Days*	*Pounds*	*Pounds*	*Days*	*Pounds*	*Pounds*	*Days*	*Pounds*
A–13	9.0	29	0.31	18	25	0.72	9	15	0.60
A–18	12.0	29	.41	27	21	1.29	18	19	.95
A–29	.7	44	.02	5	25	.20			
A–41	2.6	44	.06	2	25	.08			

Although the two cows of average production (A–29 and A–41) ate very little bone meal, the two high-producing cows (A–13 and A–18) ate liberal quantities. The coarsely ground bone meal contained slightly less ash and consequently more organic matter than the finely ground bone meal, which may have been responsible for the greater consumption of the coarsely ground. The finely ground poultry meal and the "raw" meal appear from the analyses to be identical products. The fact that the two high-producing cows ate more raw meal during the latter part of the experiment than they did of finely ground poultry meal during the first part of the experiment, may have been due to their entering the experiment with a considerable mineral reserve.

This work indicates that good producing cows, fed a ration estimated to be deficient in phosphorus, will eat generous quantities of bone meal, while poorer producers having a smaller demand for minerals will eat very little. It thus appears likely that if cows are allowed free access to a palatable bone meal they will tend to adjust their consumption to meet their needs.

HEAVY VERSUS LIGHT FEEDING PRIOR TO CALVING

An experiment was conducted to compare the relative effects on the production of dairy cows, of heavy and light feeding before calving. In this experiment it was intended that the cows should be put in a good state of flesh by feeding them 12 pounds of grain per cow per day for an average of two months previous to calving, in order to compare their production with that of the same cows when put in only a medium state of flesh before calving, by feeding 4 pounds of grain a day for a similar period. The grain mixture used in heavy feeding was 8 pounds of hominy feed, 3 pounds of wheat bran, and 1 pound of old-process linseed meal; that used in light feeding was 3 pounds of wheat bran and 1 pound of old-process linseed meal. All of the cows received either pasture or all the alfalfa hay and silage they would eat.

At the time experimental feeding was started and also at the time of calving the condition of each cow was observed. This was expressed as a rating, with 100 as very fat and 70 as a medium state of flesh, or what would be termed good milking condition. Weights taken on the first, second, and third days of each month also helped to show the condition of the cow after calving. The data for 10 cows which had comparable periods of heavy and light feeding are given in Table 6.

TABLE 6.—*Effect of heavy and of light feeding of cows before calving upon the production of milk and butterfat after calving*

Cow No.	Breed	Plane of feeding	Age of cow when feeding experiment started		Period of feeding	Time cow was dry	Condition at beginning and end of feeding experiment[1]		First weight of cow taken after calving	Production for 90 days after calving		
							Beginning	End		Milk	Butterfat	
			Yrs.	*Mos.*	*Days*	*Days*	*Rating*	*Rating*	*Pounds*	*Pounds*	*Per cent*	*Pounds*
444	Jersey	Heavy	9	5	45	65	65	65	1,002	2,508.9	4.81	120.61
		Light	8	6	61	38	65	55	907	1,881.4	4.85	91.21
485	do	Heavy	9	9	49	57	75	80	932	3,731.2	5.10	190.37
		Light	8	8	61	60	75	75	950	3,729.8	5.00	186.62
A-20	Grade Holstein	Heavy	4	9	74	83	70	85	1,211	3,068.6	3.37	103.31
		Light	5	9	67	89	75	75	1,245	3,259.4	3.74	121.79
A-14	do	Heavy	5	6	60	129	75	80	1,134	3,705.8	3.38	125.34
		Light	6	5	63	86	75	75	1,163	4,024.4	3.50	140.92
436	Jersey	Heavy	9	5	57	63	85	85	930	2,139.8	4.24	90.70
		Light	10	10	82	255	80	85	1,015	2,671.3	4.57	122.02
411	do	Heavy	11	5	59	126	90	85	1,012	2,331.5	4.55	106.14
		Light	10	5	68	123	85	85	1,030	2,299.2	4.22	96.95
480	do	Heavy	7	8	62	70	85	85	1,041	2,410.7	5.67	136.71
		Light	6	7	66	77	85	85	1,022	1,894.7	6.10	115.53
438	do	Heavy	9	6	70	62	75	75	1,079	1,781.1	5.37	95.61
		Light	10	7	73	134	75	70	1,061	2,628.6	6.31	165.85
455	do	Heavy	8	0	42	138	70	75	787	2,179.1	4.71	102.70
		Light	9	1	51	96	70	75	846	2,507.2	4.27	106.98
277	Holstein	Heavy	7	2	51	61	60	60	1,286	4,163.9	3.54	147.37
		Light	6	3	58	45	80	80	1,180	5,053.0	3.59	181.17
Average:												
Heavy					57	85	75.0	77.5	1,041.4	2,802.1	4.35	121.89
Light					65	100	76.5	76.0	1,041.9	2,994.9	4.44	132.90

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[1] See text for explanation of rating.

The average time that the cows were on experiment during the period of light feeding was eight days longer than the average time of heavy feeding. The average period they were dry was 15 days longer than the period of heavy feeding, but this difference is due chiefly to the large difference for one cow, No. 436. The system of scoring used indicated but little improvement in the condition of the cows through liberal feeding, while those lightly fed about held their own. At the time of calving, or soon after, both the scores and the weights show little or no difference in the condition of the cows in regard to flesh. The average time between calving and weighing was 11 days for the lightly fed cows and 18 days for the heavily fed cows. Of the 10 cows, 4 gave more milk for a 90-day period following calving when fed heavily and 6 gave more when fed lightly. When lightly fed, the cows gave 6.5 per cent more milk and 9 per cent more butterfat than when heavily fed. The production record was limited to 90 days because the cows were needed for other experiments which did not permit comparable feeding methods to be followed.

The fact that the cows gained very little in weight during the two months of liberal feeding indicates that more time than this is required to fatten a cow before calving. The results show that liberal feeding before calving does not, in itself, lead to increase in milk production. From these results it also seems probable that in case it is found desirable to have cows fat at calving time they must be so fed during lactation as to leave them in good condition at the time of drying off.

FEEDING HEMPSEED MEAL

Hempseed meal, the ground residue from the expression of oil from hempseed, which was prepared under the direction of a specialist of the Bureau of Plant Industry, was fed to nine cows to determine the effect of this material upon the flavor and odor of milk. The milk samples were judged by market-milk specialists of the Bureau of Dairy Industry. No bad effects from feeding this meal were observed.

Palatability tests with these nine cows, as well as with others, indicated that hempseed meal is fairly satisfactory in this respect. When a mixture of equal parts of hempseed meal, wheat bran, and hominy feed was fed, only one of the nine cows refused her feed more than once. Not enough of the meal was available to test its nutritive value.

FEEDING BEET PULP DRY AND WET

In view of the readiness with which dried beet pulp absorbs water, it seemed reasonable to suppose that if cows were allowed plenty of water to drink, soaking of the pulp might just as well take place in the paunch of the cow as before feeding. Feeding the pulp dry is decidedly more convenient than feeding it wet. A preliminary trial with two grade cows for two 12-day periods indicated that the dry pulp was fully as palatable as the wet, and the production of milk was as great in one case as in the other.

Twelve cows, in two groups of six each, were fed for 60 days by the reversal method, as shown in Table 7. The beet pulp took the place of silage in the ration. The amount of beet pulp fed varied between 6 and 10 pounds per cow per day, depending upon the size of the cow. The pulp fed wet was soaked during the time from one feeding to the next with three times its weight of water. In addition to the pulp the cows were given all the alfalfa hay they would eat and grain in quantities at least equal to the Savage requirements.

TABLE 7.—*The effect of soaking beet pulp before feeding, upon amount of hay eaten, amount of milk produced, and gain in body weight*

Cow No.	Period	Beet pulp fed	Grain fed	Hay eaten	Beet pulp (dry basis)	Milk produced	Gain (+) or loss (−) in body weight	Period	Beet pulp fed	Grain fed	Hay eaten	Beet pulp (dry basis)	Milk produced	Gain (+) or loss (−) in body weight
			Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*			*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
A-36	1	Dry	145	472	266	777.7	−6	2	Wet	116	557	270	731.0	+6
277	1	do	378	591	266	1,438.9	+11	2	do	406	630	265	1,455.7	+47
602	1	do	444	291	240	1,132.9	+24	2	do	477	278	231	1,035.3	+28
636	1	do	255	334	236	586.2	−14	2	do	176	397	240	570.6	+18
659	1	do	432	410	180	1,013.2	+22	2	do	422	414	180	983.9	0
811	1	do	372	482	264	1,420.6	−29	2	do	361	515	192	1,200.3	+7
Average per cow per day			11.26	14.33	8.07	35.39	+.04			10.88	15.78	7.66	33.20	+.59
A-30	1	Wet	288	543	270	1,218.1	−12	2	Dry	282	689	270	1,101.0	−2
A-32	1	do	432	542	270	1,526.0	+23	2	do	426	575	270	1,450.6	+30
455	1	do	285	258	180	767.5	−1	2	do	270	296	180	739.6	−1
632	1	do	354	332	210	840.1	0	2	do	321	346	210	831.9	−3
656	1	do	507	256	210	1,164.0	+17	2	do	515	275	210	1,078.8	+17
809	1	do	226	611	300	1,043.4	+1	2	do	210	659	300	988.2	+22
Average per cow per day			11.62	14.12	8.00	36.44	+.16			11.24	15.78	8.00	34.39	+.35
Average per cow per day, both groups:														
Dry fed			11.25	15.06	8.03	34.89	+.20							
Wet fed			11.25	14.95	7.83	34.82	+.37							

Although the cows gave a trifle more milk and consumed very slightly more hay when fed the dry pulp than when fed wet pulp, the differences are negligible. The method of feeding the beet pulp had no effect upon the percentage of fat in the milk. Both groups of cows gave slightly richer milk during the second period. In changing one group of cows from dry pulp to wet pulp the average increase in fat content of the milk was 0.14 per cent; in changing the other group from wet pulp to dry pulp the increase was 0.13 per cent. The cows fed the wet pulp showed the greater gains in weight. Dry pulp was refused entirely, or in part, 5 times out of a possible 720, and wet pulp 27 times. Apparently any difference in palatability was in favor of the dry pulp. Frequent observations showed no noticeable difference in the consistency of the feces due to the method of feeding the pulp. The cows were turned out in the yard twice a day for water.

COMPARISON OF THE CONSUMPTION OF DIFFERENT HAYS

The following hays were fed, in seven 20-day periods, to 10 cows in the order given: No. 1 alfalfa, No. 2 soybean, No. 3 alfalfa, No. 2 clover, No. 2 alfalfa, No. 1 timothy, and No. 1 alfalfa. Silage was fed at the rate of 3 pounds daily per 100 pounds of live weight. In the case of Holsteins, grain was fed at an average rate of 0.4 pound of grain for each pound of milk produced above 16 pounds; and in the case of Jerseys, 0.6 pound of grain for each pound of milk produced above 10 pounds, adjustment being made the first of each month. The results of this experiment are given in Table 8 and in Figure 1. The data given are for the last 10 days of each 20-day period, the first 10 days being required to adjust the quantity of hay to the appetite of the cow and to accustom the cow to the hay.

Table 8.—*Effects of feeding cows various kinds of hay upon amounts of hay eaten, milk produced, and decline in milk yield*

[Average for 10 cows]

Period No.	Kind of hay fed	Average quantity of hay eaten daily per cow	Average daily yield of milk per cow	Average decline in milk yield [1]
		Pounds	*Pounds*	*Per cent*
1	No. 1 alfalfa	14.4	28.8	----------
2	No. 2 soybean	12.4	27.6	4.7
3	No. 3 alfalfa	12.8	26.3	3.5
4	No. 2 clover	8.9	24.4	8.3
5	No. 2 timothy	12.6	23.0	4.6
6	No. 2 alfalfa	13.0	22.3	5.0
7	No. 1 timothy	13.0	20.8	5.6
8	No. 1 alfalfa	14.8	20.7	2.6

[1] By comparison of last three days of 20-day period with last three days of preceding period.

In this experiment more of the alfalfa was consumed than of the other hays, and soybean hay and timothy hay were consumed in about the same amounts, but the clover ranked far below the others. The possibility that mildew or other affection of the clover may have lowered its palatability is suggested, although the results obtained corroborate those obtained by the nutrition laboratory at the Beltsville station in other experiments on palatability of hays. The better grades of hay are eaten in larger quantities than are the poorer grades. Figure 1 shows that a change from timothy to alfalfa retarded the decline in milk production. Part of this may have been due to the fact that the protein of the grain ration was adjusted for alfalfa hay, and that the cows received insufficient protein when fed the timothy. On comparing the percentages of decline in production, it is seen that of the hays used, No. 1 alfalfa was the most effective and No. 2 clover the least effective in maintaining the milk flow.

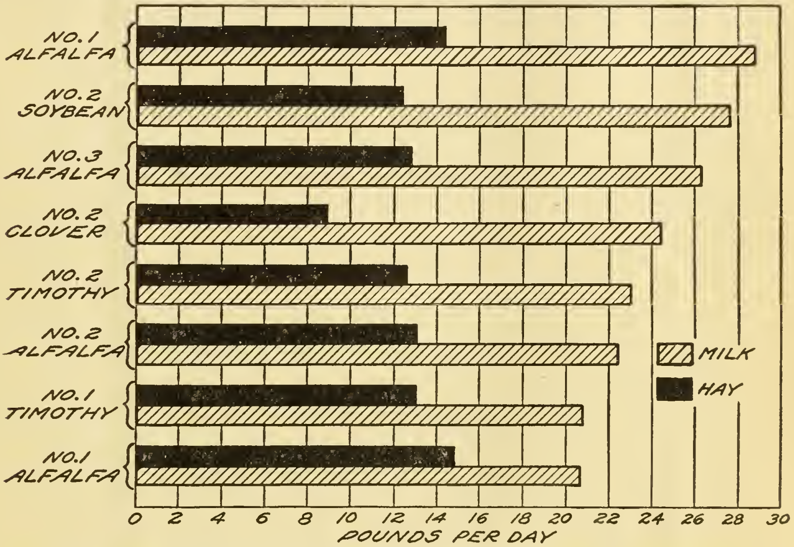

FIGURE 1.—Average quantity of different hays eaten and milk produced, per day per cow, by a group of 10 cows during the last 10 days of a 20-day feeding period for each hay

VARIATION IN BUTTERFAT TEST FROM ONE MILKING TO ANOTHER

It is well known that when cows are milked twice a day and the intervals between milkings are unequal the milk obtained after the shorter interval will test higher in butterfat than that obtained after the longer interval. However, if the shorter intervals are multiplied, as in milking cows three or four times a day, the percentage of butterfat is not increased. This led to the theory that the percentage of butterfat in the milk of a cow is fairly constant for that particular cow and that the variations in fat content of different milkings actually found in practice are due either to a temporary check in fat secretion, possibly on account of udder distention, or to a lagging of the fat in the flow to the milk cisterns but that in any event such fat is recovered at the subsequent milking or milkings. According to this theory, therefore, equal intervals should result in equal fat tests; intervals of say 16, 4, and 4 hours should result in a somewhat higher test for the first 4-hour interval than for the 16-hour interval but a lower test for the second 4-hour interval than for the first 4-hour interval, because the fat left from the 16-hour interval would have been recovered, either wholly or in part, at the end of the first 4-hour interval. It was also thought that a supplementary stripping 30 minutes after each milking at 16, 4, and 4 hour intervals might recover all the fat that had lagged behind, so that this fat added to that obtained at the regular milkings would make the butterfat test approximately equal for the different intervals. By this theory, also, the percentage of butterfat for 24-hour intervals should not be affected by changes in the intervals of milking.

The following experiment was carried out: Cow A–38, which had just finished a year's work in the test barn, was milked for five days at 8-hour intervals, then for five days at 16, 4, and 4 hour intervals, then for five days at the same intervals with an additional stripping 30 minutes afterwards. At the start of the experiment this cow was yielding about 22 pounds of milk a day. The results are shown in the first part of Table 9.

Table 9.—*Comparison of the quantities of milk and butterfat yielded by two cows when the intervals between milkings were the same length and when they were of different lengths*

COW A-38

Period and interval	First milking at 5 a. m. (8 hours)			Second milking at 1 p. m. (8 hours)			Third milking at 9 p. m. (8 hours)			Average daily production		
	Milk	Butterfat		Milk	Butterfat		Milk	Butterfat		Milk	Butterfat	
	Pounds	*Per cent*	*Pounds*	*Pounds*	*Per cent*	*Pounds*	*Pounds*	*Per cent*	*Pounds*	*Pounds*	*Per cent*	*Pounds*
First 5-day period; milking at equal intervals	7.6	3.77	0.288	7.6	4.01	0.305	7.2	3.95	0.284	22.5	3.90	0.878
	5 a. m. (16 hours)			9 a. m. (4 hours)			1 p. m. (4 hours)					
Second 5-day period; milking at unequal intervals	12.0	4.10	0.492	3.7	5.23	0.195	3.5	4.34	0.154	19.3	4.36	0.841
	5 a. m. (16 hours)			9 a. m. (4 hours)			1 p. m. (4 hours)					
Third 5-day period:												
Milking at unequal intervals	11.3	3.85	0.434	3.1	5.05	0.155	2.9	4.12	0.120			
Stripping 30 minutes after milking	.6	6.94	.043	.5	6.24	.030	.6	5.34	.033			
Total or average, third period	11.9	4.01	.477	3.6	5.14	.185	3.5	4.37	.153	19.0	4.29	0.815
COW A-21												
	5 a. m. (8 hours)			1 p. m. (8 hours)			9 p. m. (8 hours)					
First 5-day period; milking at equal intervals	11.4	2.80	0.319	10.8	2.84	0.307	10.5	2.88	0.302	32.7	2.84	0.928
	5 a. m. (16 hours)			9 a. m. (4 hours)			1 p. m. (4 hours)					
Second 5-day period; milking at unequal intervals	18.6	2.61	0.486	4.9	4.30	0.213	4.6	3.52	0.160	28.1	3.06	0.859
	5 a. m. (8 hours)			1 p. m. (8 hours)			9 p. m. (8 hours)					
Third 5-day period; milking at equal intervals	10.2	3.10	0.317	9.8	2.94	0.287	9.5	3.04	0.290	29.5	3.03	0.803

The small variations in the butterfat tests of the milk from this cow when the intervals between milkings were of the same length and the pronounced variations when the intervals were of different lengths bear out the theory that when the intervals between milkings are the same the butterfat tests are the same; that when a short interval follows a long interval the butterfat test of milk from the short interval is higher than that of the long interval; and that the milk from a similar second short interval tests lower than that from the first short interval. The results did not bear out the idea that if the milk was stripped out again 30 minutes after each milking, and these strippings added to the previous milking, the butterfat tests for the three intervals would be approximately equal; in fact, the strippings had only a slight effect in changing the general result. However, by comparing the results of milking at unequal intervals during the second 5-day period with those of the third 5-day period, it will be seen that the 24-hour fat percentages were about the same, but that the tests for the 5, 9, and 1 o'clock milkings of the third period (not including strippings), were lower in every case than for the corresponding intervals in the second period without supplementary stripping. This shows that the fat in the follow-up milkings was obtained at the expense of the fat in the succeeding milkings. Although the higher test for the day obtained with unequal milking periods might be attributed, at least in part, to the natural increase caused by advance in stage of lactation, it appears that this increase, 0.4 per cent, is too great to be explained entirely by the advance in stage of lactation. Another experiment with a cow, No. A–21, that had been fresh about four months and was giving 32 pounds of milk a day, yielded a similar result.

In this second experiment the cow was milked for 5 days at equal intervals of 8 hours, then for 5 days at intervals of 16, 4, and 4 hours, and finally for 5 days at equal intervals as in the first 5 days. The results, given in the second part of Table 9, confirm those of the first experiment, although the increase in percentage of butterfat for the days when this cow was milked at unequal intervals was somewhat less than in the first experiment. It appears, therefore, from these two experiments, that the percentage of fat for the day can be changed to a slight extent by varying the intervals of milking within the day. The theory as to equal butterfat tests for the day, regardless of the intervals between milkings, is not entirely borne out.

COOPERATIVE PASTURE EXPERIMENT

The objects of this experiment, conducted in cooperation with the Bureau of Plant Industry,[1] were to study the effects of rotation grazing as compared with continuous grazing, the effects of fertilizing, and to compare Reed canary grass with a grass and clover mixture.

PLAN OF THE INVESTIGATION

A 12-acre field at the Beltsville station was divided into six 2-acre pastures. This field had been seeded in the fall of 1928 and partly reseeded in the spring of 1929, with a mixture of grasses and clovers consisting of Kentucky bluegrass, 12 pounds; redtop, 3 pounds; timothy, 4 pounds; orchard grass, 4 pounds; meadow fescue, 4 pounds;

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[1] The agronomic phases of this work were in the charge of H. N. Vinall, senior agronomist, and Mason Hein, assistant agronomist, Bureau of Plant Industry.

Italian ryegrass, 8 pounds; perennial ryegrass, 4 pounds; red clover, 3 pounds; white clover, 2 pounds; alsike clover, 2 pounds; common lespedeza, 6½ pounds; and Korean lespedeza, 4 pounds. The fertilizer consisted of 400 pounds of superphosphate (16 per cent), 100 pounds of muriate of potash, and four applications of a nitrogenous material per acre each year. The phosphate and potash were both applied at one time in the fall or winter. On three of these pastures 100 pounds of nitrate of soda (Chilean) per acre were put on in each of four applications during the growing season, beginning about March 15. On the other three pastures 300 pounds of sulphate of ammonia were used instead of the nitrate. The pastures were grazed in rotation, at first with milking cows for about four days, and then with young stock immediately afterward for the same length of time. The modified Hohenheim system of pasture management as practiced in the British Isles differs from this system in that in the spring certain of the pastures are skipped in the rotation and allowed to produce hay. After the hay is cut, the pastures are again included in the rotation. In the system used at Beltsville more cattle were placed on the pastures during the season when the grasses were growing rapidly, in order to prevent them from reaching the haymaking stage. In spite of the heavy grazing, certain spots of grass were avoided by the cattle, and the grass on these sometimes reached a height of a foot or more. For this reason the mower was run over the pastures and if the clippings were of any considerable amount they were raked up, weighed, and proper allowance made in the statement of yields.

In order to compare continuous and rotation grazing, an adjoining 4-acre field was seeded in the spring of 1929 with the same mixture of grass and clover that was used on the 12-acre field described above. This field was fertilized the same as the 12-acre field. The only difference was that this field was continuously grazed, whereas the 12-acre field was grazed in rotation.

Another 4-acre field was seeded and grazed in the same manner as the 4-acre field described, but no fertilizer was applied. A comparison of the 4-acre fields shows the influence of the fertilizer.

A field of 3.77 acres was seeded to Reed canary grass in the spring of 1929. This was not fertilized and was continuously grazed for comparison with the second 4-acre field.

An effort was made to balance the groups of cattle on all the fields with reference to breed, age, weight, condition, stage of lactation, and quantity of milk produced. The closeness of grazing also received attention. Animals were put on or taken off the pastures in such numbers as would result in all pastures under comparison being grazed equally closely. However, in doing this, care was taken to have as many animals as possible remain continuously upon the pastures under comparison.

Supplementary feed was given in such quantities as were considered necessary to support the milk production with but little gain or loss in body weight. Early in the season only those cows producing more than 1 pound of butterfat a day were given any supplementary feed, but later in the season all cows received an almost complete winter ration.

The intent of this plan was to make the consumption of grass in a day's grazing on one pasture equal to that in a day's grazing on the other pastures, and thus permit the number of days of grazing to be used as the main if not the sole measure of comparison. On account of the small number of animals that could be grazed on such small fields, it was impossible to keep the different groups perfectly balanced in respect to the factors mentioned above. The differences between the results obtained with the various pastures are, therefore, manifest in several ways of which the principal ones are days' grazing, milk produced, gain or loss in weight, and supplemental feed eaten. The need for some method of expressing the value of a pasture in a single term was apparent. The digestible-nutrients method explained below apparently filled this need in a fairly satisfactory manner.

The digestible nutrients required by the cattle for maintenance and milk production were estimated from one of the feeding standards. From these were deducted the digestible nutrients eaten in the supplemental feeds, the result being the digestible nutrients credited to the pasture. This method differs from the one used at the Huntley, Mont., station [2] only in that the results are expressed in terms of digestible nutrients rather than in the quantities of hay and silage required to furnish the digestible nutrients. Although this method was satisfactory in estimating nutrients required for maintenance and milk production, it was not so satisfactory in estimating nutrients for gain and loss in weight. In the work reported in this publication, for want of a more reliable factor, 3 pounds of digestible nutrients were considered as the requirements for 1 pound of gain in weight. Until such requirements are more accurately determined, it would be desirable so to manage the dairy cattle in pasture experiments that there will be little gain or loss in live weight.

RESULTS FOR THE SEASON OF 1930

As the 12-acre field was seeded in the fall, the growth on it was greater early in the spring than that on the fields seeded in the spring. For this reason the data on the various pastures for 1929 were omitted. In 1930 the grass on all the pastures ceased growth almost entirely after about June 20. Nevertheless, some animals were left on all the fields until September 22, for the purpose of simulating actual farm conditions. The clippings made this year were not sufficient in amount to warrant raking them up. On account of the dry weather only two of the four nitrogen applications were made. The data in Table 10 are given in two ways: (1) for the period April 15 to June 30, inclusive, during most of which time the grazing was good, and (2) from April 15 to September 22, the date when all the cattle were removed from the pastures. A record of the precipitation in the vicinity during the seasons of 1929 and 1930 is shown in Table 13 (p. 23).

The data show that rotation grazing gave greater returns than continuous grazing. They show, too, the beneficial effect of fertilizer, although the value of the increase in yield was not quite enough in the 1930 season to pay for the fertilizer. The growth during the drought was about the same on all the fields. The cows on the

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[2] MOSELEY, T. W., STUART, DUNCAN, and GRAVES, R. R. DAIRY WORK AT THE HUNTLEY FIELD STATION, HUNTLEY, MONT., 1918–1927. U. S. Dept. Agr. Tech. Bul., 116, 48 pp., illus., 1929.

TABLE 10.—*Record, on a per-acre basis, of grazing, production, body weights, supplemental feeds, and nutrients for the various pastures during the grazing season of 1930*

Period of test	Calendar days	Cow days per acre	Heifer days per acre	Animals per acre		Production per acre		Gain or loss (—) in live weight per acre		Quantity of supplemental feed eaten per acre—				Digestible nutrients in supplemental feed per acre	Total digestible nutrients required per acre	Digestible nutrients credited to pasture per acre
										By cows		By heifers				
				Cows	Heifers	Milk	Butterfat	Cows	Heifers	Grain	Hay	Grain	Hay			
FERTILIZED, ROTATION-GRAZED PASTURES																
	Number			*Number*	*Number*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Apr. 15 to June 30	77	79	52	1.03	0.68	2,376	98.54	22	48	359	-------	164	-------	382	2,062	1,680
Apr. 15 to Sept 22	161	107	67	.66	.42	3,094	127.35	21	52	698	203	246	7	798	2,666	1,868
FERTILIZED, CONTINUOUSLY GRAZED PASTURE																
Apr. 15 to June 30	77	59	41	0.77	0.53	1,832	74.27	25	43	232	-------	123	-------	260	1,643	1,383
Apr. 15 to Sept. 22	161	80	62	.50	.39	2,462	94.68	26	55	501	157	249	8	634	2,238	1,604
UNFERTILIZED, CONTINUOUSLY GRAZED PASTURE																
Apr. 15 to June 30	77	51	34	0.66	0.44	1,645	64.01	−17	12	257	-------	96	-------	258	1,197	939
Apr. 15 to Sept 22	161	73	53	.45	.33	2,309	84.89	−13	23	546	161	182	9	620	1,762	1,142
REED CANARY GRASS, UNFERTILIZED, CONTINUOUSLY GRAZED PASTURE																
Apr. 15 to June 30	77	40	31	0.52	0.40	1,212	49.04	−48	15	196	-------	84	-------	205	869	664
Apr. 15 to Sept 22	161	63	54	.39	.34	1,877	73.65	−59	36	483	170	221	10	609	1,487	878

fertilized pastures gained in weight, while those on the unfertilized pastures lost; the heifers gained more on the fertilized than on the unfertilized pastures.

The canary grass has produced less pasturage than the mixture of grasses and clovers, and there is some difference in favor of the mixture in regard to gains in weight. In justice to the canary grass it should be stated that the stand is not as thick as that of the mixture. Probably this is due largely, if not entirely, to the small quantity of seed sown. Besides, the canary grass requires time to become established, and as it is partial to damp soil, the dry weather in July and August of 1929 and in most of 1930 was not favorable to its growth.

The digestible nutrients per acre credited to the different pastures are expressed relatively in Table 11 by using the figure 100 to denote the yield of the fertilized, rotation-grazed pastures.

TABLE 11.—*Relative yields of digestible nutrients from the different pastures for the season 1930*

	Apr. 15 to June 30	July 1 to Sept. 22
Fertilized, rotation grazed	100	100
Fertilized, continuously grazed	82	100
Unfertilized, continuously grazed	56	92
Canary grass, unfertilized, continuously grazed	40	96

The figures in Table 11 show the beneficial effects of both fertilizing and rotation grazing early in the season while the ground was still moist enough to permit a fair growth of grass. Later in the season, however, when the drought had become more severe, fertilizing helped but little and rotation grazing helped none at all. The canary grass made a little more growth during the drought than did the grass and clover mixture, in spite of the fact that the canary grass is particularly partial to a damp soil. Yields obtained from small clipped plots of both canary grass and the pasture mixture corroborate these findings.

SEASONAL GROWTH OF PASTURE GRASS

A half-acre plot of what would be termed a good grass pasture was fenced off on May 2, 1929, after cows had had an opportunity to graze it since April 23, 1929. The pasture plants were mostly Kentucky bluegrass and orchard grass with a little white clover. The only weed of any consequence was buckhorn. This plot was clipped to a height of about 2 inches with a regular farm mower at intervals throughout the season. The clippings were collected in a metal pan attached to the back of the cutter bar. The interval between clippings was about 10 days, if the grass had made sufficient growth in that time to be cut and the clippings recovered. Otherwise, clipping was deferred until the grass had made more growth. The height of grass at the time of clipping varied usually from about 4 to 6 inches. In the first cutting, there was considerable dry grass left over from the previous season. Of the green grasses, Kentucky bluegrass exceeded the orchard grass in quantity for the first clipping only. Thereafter the orchard grass was predominant over the bluegrass.

The work was continued in the same way for the growing season of 1930. The weather, however, was so dry that only five cuttings were made. No fertilizer has been applied, nor has any cultural treatment been given this plot since it was first fenced off. Data on the yields and analyses are shown in Table 12, and the monthly precipitation during the growing seasons of 1929 and 1930 is given in Table 13.

TABLE 12.—*Yields and analyses of pasture grass cut at intervals of 10 days or longer during the growing seasons of 1929 and 1930*

Date	Green weight per acre	Moisture in original material	Analyses of air-dry material							
			Moisture	Protein	Fat	Ash	Nitrogen-free extract	Fiber	Calcium	Phosphorus
1929	*Pounds*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
May 10	1,740	73. 1	8. 0	14. 0	3. 4	7. 3	41. 7	25. 6	0. 318	0. 307
May 21	930	77. 1	8. 0	16. 9	3. 5	8. 6	36. 4	26. 6	. 324	. 419
May 31	470	75. 4	7. 3	18. 4	4. 2	8. 7	36. 4	25. 0	. 341	. 448
June 10 [1]										
June 20	160	65. 4	7. 2	14. 0	3. 6	10. 4	38. 1	26. 7	. 418	. 416
July 1	440	76. 3	7. 9	19. 5	3. 8	9. 3	35. 2	24. 3	. 420	. 459
July 11	440	75. 4	7. 6	20. 0	4. 5	10. 1	35. 9	21. 9	. 440	. 589
July 23	148	69. 8	7. 6	17. 8	4. 8	9. 8	36. 2	23. 8	. 477	. 482
Aug. 12	45	45. 8	7. 5	13. 7	4. 7	8. 9	40. 0	25. 2	. 525	. 326
Sept. 12	58	50. 6	7. 7	14. 3	5. 0	6. 9	37. 5	28. 6	. 529	. 281
Oct. 24	170	72. 8	6. 8	20. 8	4. 6	9. 4	40. 0	18. 4	. 595	. 376
1930										
May 1	530	70. 6	8. 5	18. 3	4. 9	7. 2	40. 0	21. 1	. 412	. 337
May 13	522	65. 7	8. 0	13. 9	4. 2	6. 7	40. 5	26. 7	. 320	. 340
May 27	480	61. 2	6. 5	12. 5	3. 9	6. 1	42. 3	28. 7	. 352	. 326
June 19	284	62. 5	6. 3	13. 7	4. 6	6. 8	41. 6	27. 0	. 459	. 357
Oct. 9	24	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)

[1] Gate found open, mowed, but clippings not saved. [2] No sample taken for analysis.

TABLE 13.—*Precipitation by months at or near Beltsville, Md., during the growing seasons of 1929 and 1930*

	March	April	May	June	July	August	September	October
Average [1]	3 63	3. 47	3. 88	4. 02	4. 44	3. 93	3. 22	2. 64
1929 [2]	2. 91	6. 48	2. 92	7. 09	1. 06	1. 65	2. 33	4 43
1930 [3]	2. 13	3. 80	1. 05	2. 07	. 38	. 59	. 81	. 21

[1] 44 years, College Park, Md., record [2] College Park, Md., record. [3] Beltsville, Md., record.

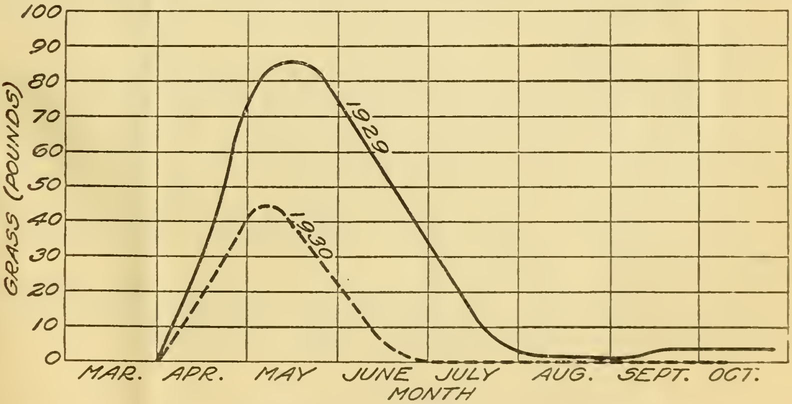

FIGURE 2.—Growth of grass expressed in green weight per acre per day for the growing seasons of 1929 and 1930

In 1929 the total weight of green grass recovered in the clipping was 4,601 pounds per acre, and, after allowing 1,000 pounds for th grass that was grazed, the total yield was estimated at about 5,60 pounds per acre. The average content of dry matter in the green grass was 26.27 per cent. The total yield of dry matter per acre for the season is thus estimated at 1,471 pounds. The dry weather in July and August caused an almost complete cessation of growth.

In 1930 the total yield of green grass per acre was only 1,840 pounds. The average content of dry matter was 35.40 per cent, making the total yield of dry matter 651 pounds.

The analyses permit but few definite conclusions, as several factors operate to complicate the situation. The flora is constantly changing throughout the season, the precipitation varies, and the growth of most grasses slows down as the season advances. The correlation between dry weather and content of dry matter in plants is well known. By comparing the clippings on June 20, August 12, and September 12 of the 1929 season and most of those in 1930 with the remainder, it appears that low yield and low protein content go hand in hand. Also there seems to be a certain correlation between low yield and low phosphorus content, as indicated by the analyses of the samples taken on August 12 and September 12 of the first year and all of those taken the second year. In 1929 the calcium increased steadily throughout the season; in 1930 the same thing happened except for the first sample.

The phase of this work which appears to be of the most practical importance, however, has to do with the quantity rather than the quality of the pasture grass. In the season of 1929, as shown in Figure 2, maximum growth occurred about the middle of May, the daily growth of green grass at that time being about 85 pounds per acre. The rate of growth then declined rapidly, until in August, September, and October the yield was only 2 to 4 pounds per acre per day.

In the grazing season of 1930 the peak of production was again reached in May. This, however, was only about half as great as the peak reached the preceding season. Two factors were responsible for this difference. Although the main reason probably was the lower precipitation in 1930, there can be no doubt that the fertility had been depleted to some extent by the removal of the previous year's growth. After the latter part of June there was a complete cessation of growth.

If it is estimated that a cow will eat only 70 pounds of grass a day, it will be seen that this plot in the first year yielded 80 cow-days of grazing, but in the second year it yielded only 26 cow-days of grazing. These two seasons, expecially the latter, have both been unusual as regards rainfall, but there is no doubt that the growth of grass usually slows up rapidly after the peak of production is reached. There was a marked decline in yield in June, 1929, despite a precipitation in excess of normal. (See Fig. 2.)

These results indicate the desirability of having ready additional pasturage or other feed to supplement the regular pastures early in summer when the grass production begins to fall off.

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